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Beal Lake Habitat Restoration

U.S. Department of the Interior
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Abstract

The Beal Lake Restoration Project (the project) is located on Havasu National Wildlife Refuge in Needles, California, within the historic floodplain of the lower Colorado River. When completed, it will include over 200 acres of cottonwood, willow and mesquite riparian habitat. Prior to restoration, Beal Lake was approximately 225 acres of shallow, low quality aquatic habitat. This lake was dredged to deepen it beginning in 2001, and the dredge material was distributed over adjacent areas, to be planted at a later date with native vegetation. Container plants grown in nurseries, cuttings and seeds have been used at the site. Phase 1 of the project, which is the focus of this report, resulted in 55 acres of cottonwood (*Populus fremontii*) and willow (*Salix gooddingii, S. exigua*) along with some naturally established arrowweed (*Tessaria sericea*) and saltcedar (*Tamarix ramosissima*) . Areas that contain saline soils will be planted with salt-tolerant shrubs (*Atriplex spp., Baccharis spp.*) and/or wetland plants such as bulrush (*Scirpus californicus*). This report will be updated as future phases of the project are completed.

Introduction

The Beal Lake Restoration Project (the Project) began as a partnership between the U.S. Fish and Wildlife Service, Havasu National Wildlife Refuge (HNWR), Needles, California, the Bureau of Reclamation's Lower Colorado Regional Office in Boulder City, NV (USBR), and Ducks Unlimited (DU). Originally, DU's interest in the site focused on improving waterfowl habitat and creating moist soil units adjacent to the lake. Preliminary soil testing and site evaluation determined that the sandy texture of the soils in the vicinity would prevent the development of moist soil units, but would allow re-vegetation with native plants and the development of aquatic refugia for native fish in Beal Lake. The development of habitat for Southwestern Willow Flycatchers and other terrestrial and marsh species of concern is the focus of this report.

USBR is interested in quantifying conditions that result in successful habitat restoration and improving our efficiency and effectiveness in future projects under the Lower Colorado River Multi-Species Conservation Program (USBR 2004 in prep.). The re-vegetation of the site was divided into 3 phases. Phase 1, involves clearing and preparing approximately 55 acres for planting with native cottonwood, willow and various salt tolerant native shrubs and groundcovers (Figures 1 and 2). Phase 2 will restore another 48 acres of cottonwood and willow and Phase 3 will restore 100 acres of mainly honey and screwbean mesquite (*Prosopis glandulosa var. torreyana and P. pubescens*) (Fig.2).

The Project is located south of Needles, CA, between Topock Marsh to the northeast and Beal Lake to the southwest. Originally, the site was dominated by arrowweed and saltcedar, with sparse cattail (*Typha latifolia*) and bulrush in wetter areas. The material from the dredging of Beal Lake in 2001-02 covered this at first, but these species soon re-established. Re-vegetation of riparian habitat adjacent to the lake began in late 2002 and continues to the present. This report describes Phase 1 of the project including various methods of creating functioning riparian habitat with as little non-native vegetation encroachment as possible.

Materials and Methods

Soil Testing

Prior to construction, analysis of aerial photos indicated distinct differences in vegetation types and densities within the proposed planting area. Based on this, soil sampling was conducted to determine if this visual difference translated to soils higher in salts and if so, salt tolerant plants could be planted in these areas. Prior to planting, one soil sample per field or approximately 1 sample per 3.5 acres was taken for analysis of salinity, soil texture and depth to groundwater. Sample size refers to number of individual holes from which soil was collected. All soils were collected with soil augers measuring 16 cm x 10 cm at a minimum of three depths per sample and analyzed at Reclamation's Lower Colorado Regional Laboratory in Boulder City, Nevada. Analysis of soils followed the protocol of the U. S. Department of Agriculture's 1996 methods manual (USDA 1996). Soil salinity is reported as a measure of electro-conductivity (EC) in milli-Siemens per centimeter (mS/cm); texture is reported in percentages of sand, silt and clay per sample. Sand is defined as particles between 0.5- 2 mm, silt is between 0.002-0.05 mm and clay is less than 0.002 mm (Kilmer 1982, USDA 1996).

Nutrients were not analyzed at the time the first soil samples were taken as some literature (Asplund and Gooch 1988) and personal communications with experts in the field (Pat Shafroth, USGS, Ft. Collins, CO) indicate that nutrients may not be a significant factor in natural establishment of cottonwood and willow from seed. Asplund and Gooch (1988) use the term "inorganic surface" to describe the alluvium where these species germinate. However, Marler et al. (2001) report a clear benefit to cottonwood and willow from elevated nutrient levels provided by treated effluent. It is possible that these species will establish naturally with low nutrient levels, but also benefit if it is provided. Regardless, after planting, a visible difference in vegetative growth and distribution in some fields was observed and soil nutrients were then analyzed to assist in determining the cause.

Site Preparation and Irrigation

Restoration began with the clearing of vegetation, mainly sparse arrowweed (*Pluchea purpurascens*), and saltcedar (*Tamarix ramosissima*) followed by root plowing to a depth of 18 inches to remove saltcedar roots. The 55 acres were then laser leveled and divided by berms into 17 individual fields in order to irrigate each field separately (Figure 1). On 18 January 2003, 120 lbs of solum certified barley seed purchased from Fertizona, Buckeye, Arizona, was drilled in as a temporary cover crop on all fields. A non-invasive cover crop helps to stabilize the soils, prevent weed infestation, and, when it is disked into to the soils, increases moisture retention and nutrients. A Rain-for-Rent sprinkler system was used to irrigate the cover crop beginning 18 March 2003.

After testing the permanent system on 19 May 2003, flood irrigation began and is the ongoing method of irrigation at the site (Figure 3). The irrigation system includes a product cooled, variable speed, diesel driven pump with a maximum flow rate of 9,000 gpm and a total lift of 10 feet. A 1,000 gallon, above ground, double walled, concrete ConVault diesel fuel storage tank was placed adjacent to the pump. Water is pumped from a small reservoir between the Beal ditch, which runs adjacent to the east side of the site (Figure 1), and Topock Marsh. The Beal ditch connects Topock Marsh to the north with Beal Lake to the south. Water is transported to each field via 4,000 linear feet of 24 inch diameter, bell and spigot gasketed, 100 psi, SDR 41, 0.605 inch walled PVC pipe. Two separate 24 inch butterfly valves were installed to control irrigation into two portions of the irrigation system. Within each field, the 24 inch diameter main was reduced to 18 inches diameter and connected to 18 inch diameter alfalfa valves. Heavy rock was deposited around each valve to reduce erosion.

Planting Materials

Dormant cuttings from both cottonwood and willow readily sprout from cuttings if placed directly into wet soil or to the water table

(Pope et al. 1990). Cuttings can be collected on the lower Colorado River (LCR) any time after the source trees become dormant, typically November through February. If irrigated, results with poles are typically equal to using rooted container plants. However, construction of the irrigation system and site preparation activities was underway and precluded planting poles at the Beal site.

Container plants for Phase 1 (*P. fremontii, Salix exigua and S. gooddingii*) were purchased from the nursery at the Colorado River Indian Tribes' Ahahkav Tribal Preserve (CRIT). All were grown in gallon sized containers from cuttings collected on CRIT lands near Parker, Arizona in December 2002 and January 2003 and were 1-3 ft in height when planted between 28 May – 6 June 2003 and 21 January – 3 February 2004. Details on the planting in each field can be found Table 1.

Seed collection is possible from March through July along the lower Colorado River and its tributaries. On the Bill Williams River (BWR), a tributary that joins the LCR near Parker, AZ, Fremont cottonwood seed begins dispersing the first week of March, with Goodding willow following 2 - 4 weeks later (Tables 1 & 2). Patches of these early seeding trees can be found elsewhere on the LCR where cuttings or poles from the BWR have been used in restoration projects. This seeding phenology is likely due to differences in timing of historical flood events on the two rivers. On the BWR, floods are a result of heavy rainfall in late winter/early spring whereas flood events occurred on the LCR in the late spring and early summer from snow melt in the Rocky Mountains. On the LCR, cottonwood and willow begin seed dispersal later. Seeding times are also associated with latitude. Seeds were collected from various locations along the LCR using a variety of methods, depending on site conditions (Table 1). Near roads where trees could be easily accessed, they were collected using a dry-vacuum system equipped with an extended piece of PVC pipe to reach high branches and connected to a small gas generator. Seeds were vacuumed into mesh or cotton laundry bags placed inside of the dry-vacuum bucket. If trees were some distance from a road, a long pruning pole was used to cut small seed-laden branches from the trees. Seeds and/or seed pods were then either stripped from the branches or small branches were left intact with seeds still on them. All seeds and branches were transported and stored (in cloth bags) either outdoors in the shade or indoors and placed on racks to allow air movement and prevent mold and mildew. Because cottonwood and willow seeds are reported to be viable for only 1-5 weeks after maturity, depending on conditions (Stromberg 1993), seeds were collected directly from the trees and not from ground litter. No information could be found regarding the best developmental stage to collect seed from the trees. Therefore, germination and viability testing of the cottonwood and willow seeds were intended to first, measure the effects of the developmental stage of the seed and pods at the time of collection and second, to determine the effects of age of the seed at the time of testing.

Classifications of the developmental stages of seeds are based on observations in the field during spring 2003 and 2004. Pictures of most developmental stages and corresponding description and germination rates are in Figures 5a and 5b and Table 7 (information and photographs continue to be collected). Once un-opened green seed pods were shipped (overnight mail) to the laboratory, treatment of them was not controlled and unfortunately, whether they opened fully prior to testing not documented. Age of parent tree, fertilization probabilities (presence of male trees in vicinity), temperature, humidity, storage conditions, and countless other variables that may affect germination were not held constant. To confirm if age was related to viability, seeds were stored for various amounts of time and then tested to determine viability. Tetrazolium absorption testing (Leist and Kramer 2003) was performed on cottonwood seeds and direct germination testing (due to the small size of the seed) was performed on willow seed by the Arizona Department of Agriculture's State Agricultural Laboratory in Phoenix. In addition to cottonwood and willow, seeds of salt tolerant shrubs were purchased from Granite Seed, Lehi, UT, and planted in Fields N, A, and the southern edges of J and E (Tables 1 & 3) where soil salinities were high. *Baccharis sarothoides*, collected from the Pratt Restoration Site, near Yuma, AZ (Raulston 2003), and *Baccharis* sp. collected from the Bill Williams River National Wildlife Refuge (BWRNWR) were also planted.

Planting

Container Plants

Based on prior experience, container plants grown in local nurseries from cuttings started in December - January are typically ready for planting beginning in mid-April, but can be later, depending on weather conditions. Soil temperatures on the LCR can exceed 100º F by June and every effort is made to plant prior to the onset of hot weather. However, due to delays in the completion of the permanent irrigation system at Beal, planting occurred from 28 May to 6 June 2003. Cottonwoods and willows in 1-gallon containers were planted in Fields B, D, E, J, and I. These fields are along the outer perimeter of the site and were planted to physically block windborne seeds and lessen the establishment of saltcedar in the inner fields. All container plants were planted using a two-seated tree planter (Tree Equipment Design, Inc., New Ringgold, PA) pulled behind a tractor. Mesquites from 1-gallon containers were also planted in the southern half of Field A because of the higher soil salinities in this area. Although mesquites are more tolerant of saline soils than cottonwood or willow (Jackson et al. 1990), the water table in this area is also very high which may prevent long term survival of mesquites at this site. Mesquites are generally found in the higher terraces along natural river systems, where water tables are deeper and inundation by flooding is less frequent (Rosenberg et al. 1991). Because the remaining container plants were not available from the nursery by June, Fields C, L, P and O were planted with Regreen™ as a cover crop, a wheat-wheatgrass hybrid purchased from Seed Solutions, Denver, CO. Regreen™ was chosen as a cover crop because it can germinate and grow in hot temperatures, is drought tolerant, forms a dense root structure to stabilize sandy soils, and it is sterile.

Seeds

The barley cover crop was disked into the soil a few weeks prior to dispersing cottonwood and willow seed in fields F, G, H, Q, K and M. Dates and methods species planted, weight of seed per field, and other details are in Table 1. Hydroseeding involved spraying a mix of water, mulch (Conwed Fibers, Inc. pure wood fiber mulch (35 lb per 1000 gallons water), tackifier for adhesion (1 lb per 1000 gallons water), fertilizer (16% N, 20% Phosphate, 13% Sulfur; 5 lb per 1000 gallons water;) and seed onto the wet surface of each field. Field M (2.6ac) was used to determine the feasibility of hydroseeding as a method to grow cottonwood from seed. This Field was divided into seven areas of equal size, approximately 0.4 acres each. All combinations (Seed Only, Seed+Fertilizer, Seed+Tackifier, Seed+Mulch, Seed+Fertilizer+Mulch, Seed+Tackifier+Fertilizer and Seed+Mulch+Tackifier+Fertilizer) of the ingredients in the hydroseed mix, as well as

2.4 lb of cottonwood seed were sprayed onto the field on 20 March 2003, immediately after irrigating. This field was then irrigated along with all other fields according to the irrigation schedule in Table 4. At the end of the growing season, all cottonwoods in each of the seven areas were counted.

Seed-laden branches were also cut and placed directly into wet soil on site to allow for gradual wind dispersal of the seeds over the fields. Loose seed collected by stripping seed and pods from branches was also dispersed by hand onto either wet soil or the water surface of flooded fields.

At the end of the first growing season, the seeded areas were evaluated to determine what percentage of the area had developed into cottonwood and willow habitat. Vegetation classifications were created based on the percentage of dominant species observed. Perimeters of the different vegetation types were mapped using points collected with a hand-held Corvalis GPS unit. Areas with sparse cottonwood and willow, or none at all were cleared and re-seeded with willow in May and June, 2004 (Table 1).

Costs

Except for leveling the fields, seed testing and hydroseeding, all costs reported are based on work performed "in-house" by either the US Bureau of Reclamation or the US Fish and Wildlife Service (Table 8).

Results

Soils

With few exceptions, higher ECs were found in soils collected at the surface (Tables 4 & 5). Soil collected from Fields A and N had the highest ECs. For all samples at all depths, soil salinities averaged 4.1 mS/cm and ranged from 25.7 – 0.52 mS/cm (Table 5).

By July 2003, observable differences existed within and among seeded fields in density of planted and naturally established vegetation. In Field C for instance, a clear diagonal line existed with Regreen™ growing on one side and little to no vegetation of any kind on the other. In other fields such as H and M, cottonwood and willow had become established in half of the field, with arrowweed and saltcedar on the other half. In Field K, little to no vegetation of any kind was observed. To rule out soil differences (salinity, nutrients, texture) as the cause of differing vegetation in the fields, additional soil samples were taken in September 2003 from each area. No significant differences were found in EC, nitrates, organophosphates, or ammonia (ANOVA $P > 0.05$, t-test for equal variances $P > 0.05$) in areas where vegetation was growing well versus where it was sparse or solely volunteer arrowweed or saltcedar. There were also no textural differences observed, 90% of the soil samples were classified as sand. Soil samples taken from 1-3 foot depths had EC values that are well within the acceptable levels for cottonwood and willow, with somewhat higher values taken from the soil surface (Table 6).

Site Preparation and Irrigation

During the first growing season, May – October 2003, 257,640,000 gallons or 790.7 af were used for irrigation. The amount of water used by month from February through May 2004 is in Table 4.

Seeds

Field M was surveyed on 12 December 2003 to determine the number of cottonwoods established from the hydroseeding test, with results in the following table. There were a total of 551 cottonwoods counted, 212/acre, with the remaining areas covered by arrowweed. The highest number of cottonwoods was found in the Seed+Mulch+Fertilizer+Tackifier treatment

Treatment	# Cottonwoods
Seed Only	15
Seed+Fertilizer	5
Seed+Tackifier	13
Seed+Mulch	8
Seed+Fertilzer+Mulch	151
Seed+Fertilizer+Tackifier	177
Seed+Fertilizer+Tackifier+Mulch	182

area, and generally decreased with increasing distance from the irrigation valve. Preliminary results of viability of different aged seeds are shown in Tables 5a, 5b and 7. Tests indicate that seeds stored while still on the branches until dispersed may have a longer "shelf-life" than seeds stripped from branches and then stored.

Results of germination tests suggest that cottonwood seed has a higher germination rate in the early developmental stages than willows. Between 56-78% of cottonwood seeds germinated in Stages 1 and 2 whereas 18-21% of willow seeds germinated during these stages. Cottonwoods had the highest probability of germinating in Stages 3-5, willows in Stages 3–4. (Tables 5a and 5b and Table 7). As a general rule, the optimal period to collect seeds from either species is once the tree begins dispersing seeds. In willows, this usually occurred after some of the pods had begun turning slightly yellow, and in cottonwoods when some pods have begun to open slightly. Green and/or unopened pods were also present at this point, but viability in both species once these open after collection was high.

Within the seeded areas, success varied. Cottonwood and willow became established in discrete patches throughout Fields F, G, H, Q and M, while arrowweed (*Pluchea purpurascens*) and to a lesser extent, saltcedar, established in others. There were also large areas of bare sand where nothing grew, including saltcedar and other non-native weeds. At the end of the growing season in 2003, cottonwood or willow established in approximately 6 acres or 38% of a total of 15.8 acres that were seeded using the various methods described previously. Although quantitative data on growth and various habitat parameters (density, species diversity, etc.) is not yet available, trees established from seed range in size from 2-12 feet in height at the beginning of their second growing season. More diversity in species and size of plants was observed in the seeded areas than in areas where container plants were used.

The vegetation maps, based on dominant vegetation types, were used to determine which polygons within the seeded areas needed to be replanted. None of the seeded fields developed into 100% cottonwood and willow. Instead, they had mixes of arrowweed and saltcedar, as well as other volunteer shrub and groundcover species. Some patches within the following fields had high percentages of cottonwood and willow: 0.5 acres of field F with 45%, 0.1. acre of Field G with 70%, 0.5 acres of Field H with 55%, 0.2 acres of Field M with 73%, and 0.2 acres of Field Q with 65%. Field K was essentially bare sand except for a small patch of arrowweed and saltcedar.

Within Fields A and N, native salt tolerant shrubs that were hydroseeded (Tables 1 & 3), namely *Atriplex* sp. and *Baccharis* sp. and some brittlebush (*Encelia farinosa*), as well as volunteer screwbean mesquites were interspersed with saltcedar and arrowweed. These two fields were left intact to determine which vegetation would eventually dominate.

Approximately half of Fields F, G, H, Q and M were cleared following inital monitoring. The remaining vegetation was retained and consisted of mostly arrowweed and some saltcedar. Fields F and G had small, narrow bands of cottonwood and willow that were retained, and all of Field K was cleared. Clearing took place from 17 - 21 May 2004. Currently, the newly seeded fields are being kept wet on the surface and monitored for germination.

Container Plants

Container plants grew as much as 12 inches in height during the first growing season, and growth was very uniform within species. Vegetative reproduction of coyote willow has been observed within Field J, E and I and seed production was observed on many Gooddings willow, but not on cottonwoods. Currently no quantitative data is available for container plants; monitoring of survival, growth, density, and condition of these plants will begin in Fall 2004.

Costs

Expenses incurred by US Bureau of Reclamation and US Fish and Wildlife Service are listed in Table 8.

Discussion

This report is intended to be updated periodically as Phases 2 and 3 are completed and additional results of techniques become available. Currently, development for Beal Restoration, Phase 2 (Fig. 2, in yellow) is underway. The site has been cleared and leveled, soil samples have been collected, and irrigation has been installed and is functioning. The area was planted with a cover crop of Regreen™ during the week of 17 May 2004. In November 2004, portions of the site that were higher in salts were planted with 1500 screwbean mesquites, while other areas that had lower soil salinities were planted with 3000 cottonwoods. Planting of Phase 2 will continue in Spring 2005 and will be irrigated throughout the growing season. In Phase 3 (Fig. 3, in blue), most of the saltcedar and arrowweed has been cleared, leaving behind established mesquites. Irrigation infrastructure and leveling are in progress (February and March 2005). This area will be re-vegetated mainly with mesquites, using seeds and potted plants, with cottonwood and willow in suitable locations. Soil testing will be accomplished prior to planting.

For over 25 years, various entities have reported on the ecological, political, and economic aspects of habitat restoration on the lower Colorado River and elsewhere in the desert Southwest. Information is available regarding the ecology of southwestern riparian systems in general (Anderson and Ohmart 1976, Ohmart et al. 1977, Anderson and Ohmart 1984b, Asplund and Gooch 1988, Rosenberg et al. 1991, Busch 1992, Busch and Smith 1995, Briggs 1996; Briggs and Cornelius 1997, Stromberg 1998, Perriman and Kelly 2000,), specific requirements of southwestern riparian systems and species such as depth to water table, soil salinity, and soil textures (Anderson and Ohmart 1982, 1984b, Fenner et al. 1984, Jackson et al. 1990, Stromberg 1993, Friedman et al. 1995, Glenn et al. 1998, Scott et al. 1999, 2000, Shafroth et al. 1995, 1998, 2000, 2002) and various planting methods and restoration techniques (Johnson 1965, Swenson and Mullins 1985, Swenson 1989, Pinkney 1992, Briggs 1992, Taylor and McDaniel 1998, Raulston 2003, USBR 1992, 1998, 1999). Although many projects have been undertaken on the LCR over the years, there is still no secret recipe for success; each restoration project on the LCR presents a different set of problems to overcome.

The following are some practical lessons learned related to irrigating this type of site. Soils at the Beal site were extremely sandy, which can make a site particularly difficult and costly to irrigate. Although water not used by the plants themselves or lost to evaporation returns to groundwater or the river eventually, the amount of water diverted is nevertheless what is usually subtracted from the total water entitlement associated with the site. Maintenance costs include fuel for the pump, which must operate longer due to the sandy soils, as well as the labor involved in operating the pump and managing irrigation valves. Laser leveling is strongly recommended. An inch or two rise in elevation or the accidental placement of a berm during construction can interrupt irrigation and cause problems. In order to move irrigation water over the field as quickly as possible, laser leveling the fields *after* rather than prior to infrastructure installation is recommended. This will improve water movement, but winds can still move sandy soils around enough to disrupt the even flow of water across a field, so monitoring of the irrigation during the first few weeks is recommended, especially if planting seeds or small seedlings. Air temperatures and winds can also hamper efforts to keep the surface of the soils damp for cottonwood and willow seed germination and survival. The sprinkler irrigation system at Beal was adequate for the cover crop of barley and Regreen™, but may not have kept the surface wet enough for germination of cottonwood and willow seed. This irrigation method was also labor intensive and had to be continually monitored for problems. Because pipes were placed over the berms that separated fields, as well as within the fields, the irrigation lines were continually coming apart and creating erosion problems. In addition, sprinkler heads often became clogged and malfunctioned. Once the permanent irrigation was in place, flood irrigation was relatively free from maintenance problems but remains a time consuming activity.

Exploration of irrigation methods that keep the surface wet without disturbing seed continue. Irrigating into furrows, for example, has been used at other restoration sites (Raulston 2003) and in local farming operations, but would be difficult to maintain in sandy soils. Furrowing allows water within the furrows to saturate the berm between them, creating moist soil on the surface of the berm without the disturbance standard flood irrigation causes. If the site is planted with a cover crop that is then tilled into the soil after a few seasons, furrows may maintain their shape long enough for plants to become established. This irrigation method needs further investigation for use in restoration.

A long-term goal of Reclamation's restoration program is to lessen the re-establishment of saltcedar through preventive measures during site preparation and planting rather than through the constant maintenance of weeding. Costs of site preparation (Table 8) associated with the Beal project are closer to those of an undeveloped site (versus an agricultural conversion) i.e. site clearing and irrigation infrastructure were required. However, costs of site clearing at Beal were less than other areas because most of the vegetation to be cleared was arrowweed and sparse saltcedar rather than the dense saltcedar found in many places on the lower Colorado River. Most of the saltcedar which came in at Beal after the initial clearing was evenly distributed and of the same size, which indicates it was from seed rather than re-sprouting. These small saltcedars were disked and the areas were replanted with either cottonwood and willow seed or container plants. Container plants can successfully shade out these competitors, but it remains to be determined if cottonwood and willow established from seed will persist. When clearing saltcedar, deep root removal to at least 18" is essential to remove saltcedar root balls below the surface (Taylor and McDaniel 1998, Taylor 1999). Re-sprouts from existing roots grow fast and can quickly shade out native container plants or seedlings.

Currently, demonstrations are being conducted in Phase 2 to reduce saltcedar establishment by planting an outer perimeter of closely planted 1 gallon container plants or pole cuttings that serve to block wind-borne seed from reaching the interior of the field. The interior is protected with a cover crop until trees in the perimeter have matured enough to seed. The interior of the field is then disked, flooded and allowed to seed more naturally. Saline areas will be seeded with native salt-tolerant shrubs such as *Atriplex spp.*, which may help reduce non-natives from establishing in open areas between mesquites and in areas that are too saline for trees.

Establishing a cover crop prior to restoration has proven to be an invaluable tool for many practical reasons. Soils are held in place while irrigation problems are identified and repaired, including the movement (or lack of movement) of the water across the area to be planted. Growth patterns of the crop can be an indicator of problem areas and can help determine which native species should or should not be planted. Tilling in the cover crop adds organic matter and mulch to the soils, which helps reduce irrigation demands and conditions soils. In addition, contracting and construction delays are inevitable, irrigation problems can arise, and trees ordered from a commercial nursery may need to be delivered prior to when the site is ready. Conversely, trees ordered for a spring delivery may not be ready on time due to uncontrollable circumstances such as cool spring weather, and a fall delivery must be arranged, leaving the site vulnerable to weeds over the growing season. Most nurseries are not willing to hold plants beyond a few months after the specified delivery dates if the plants are ready, as space is needed for additional orders. However, these problems can be minimized significantly if a cover crop is in place and the site is stable. This allows for ample time to attend to the important details of actually planting the site, such as researching and ordering the appropriate species, collecting or ordering the appropriate seed, determining planting methods and equipment needs, and organizing a labor force among agencies or implementing a contract for planting. The resulting product will be better if those involved are not under pressure to plant.

High germination rates in the laboratory and an abundance of seed did not result in high sapling establishment as expected. Along with drying of the soil surface as a likely cause of low survival and densities of seedlings, storage conditions of seeds and time of harvest are other important factors. Seeds that are properly dried after collection have greater longevity and germination rates than those exposed to humid conditions during storage (Moss 1938, Wyckoff and Zasada http://ntsl.fs.fed.us/wpsm/Populus L., Zasada et al. http://ntsl.fs.fed.us/wpsm/salix.L.). Moss (1938) also mentions that despite moisture availability under controlled conditions, certain storage conditions may affect seeds that displayed a "sluggish vitality" long after the power to form normal seedlings was lost; these seeds germinated, but quickly died. Monitoring seedlings in the field is problematic; seedlings first appear as miniscule cotyledons that are very difficult to detect on the ground, while their roots can be an inch or more long (Moss 1938, Raulston pers.obs.).

The ability to see seedlings was so limited that walking through fields had the potential to affect results. Therefore, monitoring germination was delayed until seedlings were more visible, generally 6-10 weeks after planting. Irrigation following one method of hand seeding (loose seed stripped from branches and stored in cloth bags) not only resulted in seeds being washed to the end of the field furthest from the valve, but also may not have allowed for proper drying prior to dispersal. Sticking cut branches into the soil and allowing seeds to remain on the branch until they dry and disperse naturally may result in a more even dispersal followed by higher survival rate. Due to the difficulty in keeping cottonwood and willow seed from blowing away from the dispersal site, these two seeding methods often overlapped. Controlled experimentation both in the lab and on site along the LCR is needed to tease apart these variables.

The establishment of cottonwood and willow from seed in high densities will shade out saltcedar and has the potential to be a successful and less expensive method of restoration. Hydroseeding was moderately successful in that the mix used did help to keep seeds from washing away during irrigation at Beal. In another test of hydroseeding near Parker, AZ, no cottonwood or willow seeds germinated at all, however, the hydroseed mix used remained where it was sprayed throughout repeated irrigations. Keeping high numbers of seeds in place and evenly distributed well past germination should lead to high densities of seedlings and less infestation of weeds, but obviously this is a problem that needs further work.

Lastly, a working definition of "successful" may be needed prior to planting so that all parties involved have the same expectations of a project. Since conditions throughout the LCR can differ from site to site, this working definition may have to be site specific. It should be discussed prior to the project so that all entities involved are aware of any limitations that the site may have toward becoming "pristine" native riparian habitat. It is unlikely that any restoration site on the LCR will remain saltcedar-free indefinitely, but steps can be taken to reduce its occurrence.

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Appendix A, Figures

Figure 1. Beal Lake Restoration, Phase 1, Havasu NWR, Needles, C A. View looking south with Beal Lake at the top of the picture and the reservoir used to irrigate the fields at the bottom. Fall 2003.

Figure 2. Beal Lake Restoration, Havasu NWR, Needles, CA Phases 1(red), 2(yellow) and 3(blue). View looking south with Beal Lake at the top, Topock Marsh at the bottom of the photo, Spring 2004.

Figure 3. Beal Restoration, Phase 1, Field Layout and Irrigation Diagram

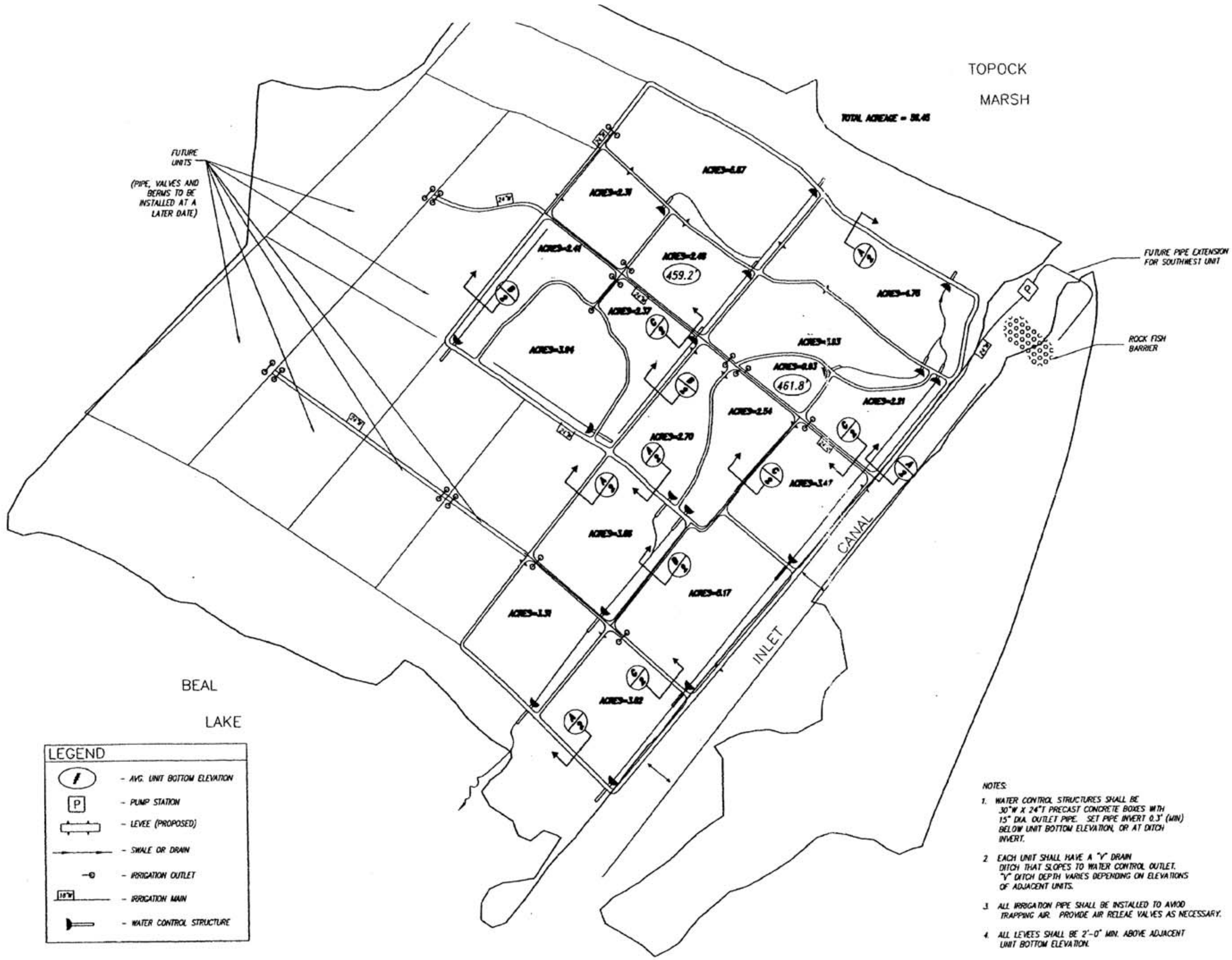
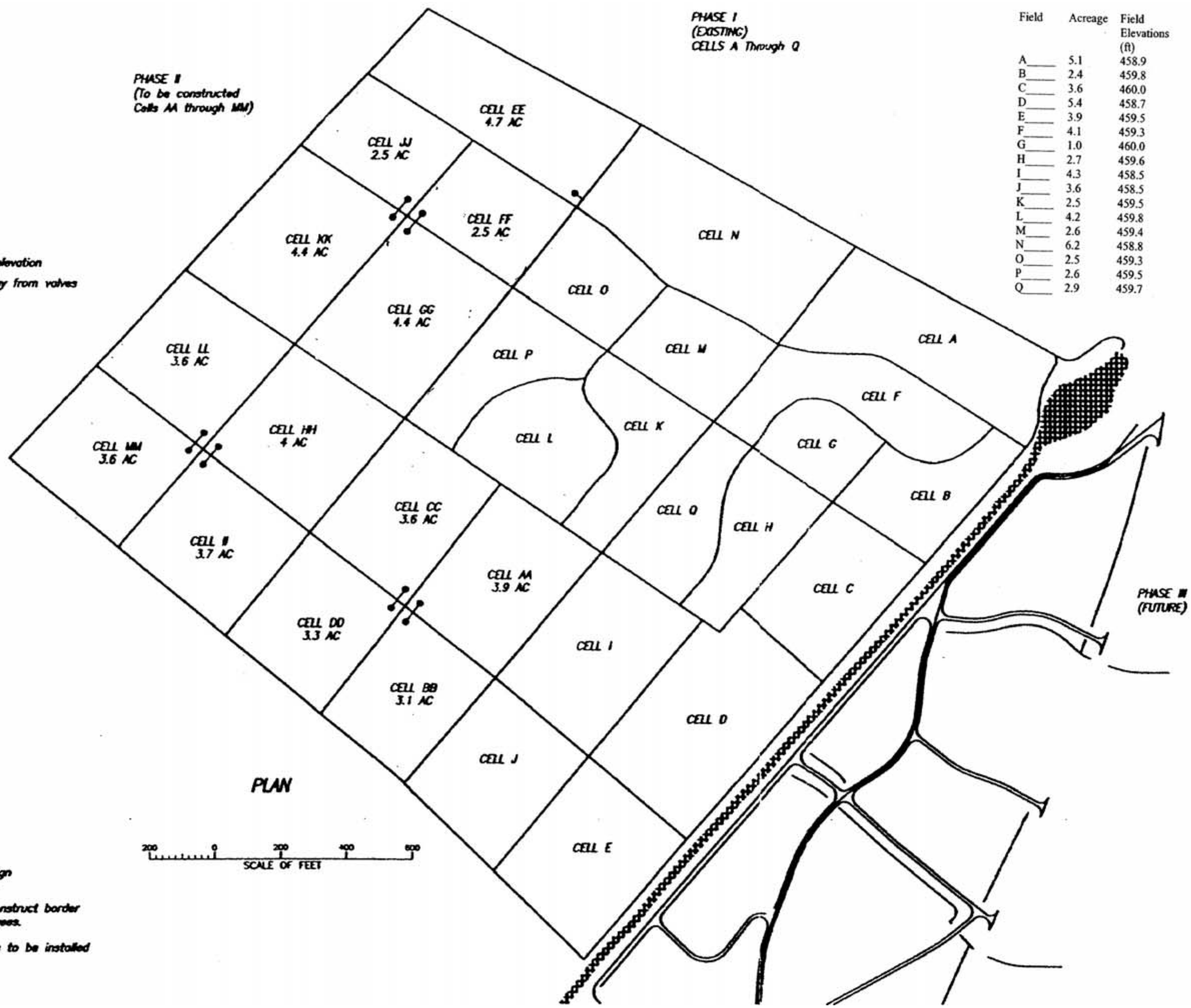


Figure 4. Beal Restoration, Phases 1 & 2, Field Layout, Acreages. and Elevations



Field	Acreage	Field Elevations (ft)
A	5.1	458.9
B	2.4	459.8
C	3.6	460.0
D	5.4	458.7
E	3.9	459.5
F	4.1	459.3
G	1.0	460.0
H	2.7	459.6
I	4.3	458.5
J	3.6	458.5
K	2.5	459.5
L	4.2	459.8
M	2.6	459.4
N	6.2	458.8
O	2.5	459.3
P	2.6	459.5
Q	2.9	459.7

NOTE: This is the average cell elevation
Grade cells to slope away from valves

CELL AA	458.7
CELL BB	458.4
CELL CC	458.8
CELL DD	458.4
CELL EE	458.5
CELL FF	459.4
CELL GG	459.7
CELL HH	458.7
CELL II	458.4
CELL JJ	459.5
CELL KK	460.2
CELL LL	459.2
CELL MM	459.0

Notes

1. Modified version of original design provided by Duck Unlimited, Inc.
2. Contractor to level cells and construct border levees, main levees, and cell levees.
3. Irrigation pipe and alfalfa valves to be installed by others.

FIGURE 5a. SEED DEVELOPMENTAL DESCRIPTION AND PHOTO GUIDE GOODDING WILLOW (*Salix gooddingii*)

DEVELOPMENTAL STAGE	DESCRIPTION OF DEVELOPMENTAL STAGE AND PHOTO	% GERMINATION
1	**All pods on tree very green and unopened when collected directly from tree.** 	**21%**
2	**Pods were collected while completely green, none opened on tree, but opened later after collected.** 	**18%**
3	**Pods were yellowish when collected, but not opened yet on tree. Opened after collected.** 	**88%**
4	**Completely open pods, fluff abundant on catkin when collected from tree.** 	**% N/A**

FIGURE 5a. SEED DEVELOPMENTAL DESCRIPTION AND PHOTO GUIDE GOODDING WILLOW (*Salix gooddingii*)

DEVELOPMENTAL STAGE	DESCRIPTION OF DEVELOPMENTAL STAGE AND PHOTO	% GERMINATION
5	**Few to no green pods remaining on tree, most seed dispersed, mostly brown, dry catkins with few seeds remaining.** 	**% N/A**
6.	**Goodding Willow Cont. Male Flower** 	

FIGURE 5b. SEED DEVELOPMENTAL DESCRIPTION AND PHOTO GUIDE FREMONT COTTONWOOD (*Populus fremontii*)

DEVELOPMENTAL STAGE	DESCRIPTION OF DEVELOPMENTAL STAGE AND PHOTO	% GERMINATION
1	Very green pods, none opened on tree when collected, unknown if seedpod opened prior to germination testing. 	78%
2	Pods unopened when collected from tree, known to have opened 1 day later. 	2003 results 56% 2004 results 58%
3	Slightly opened seed pods and/or at least one pod opened/slightly opened in cluster (photo to be inserted later-not available)	98%
4	Seed collected fully open and fluffy or tree actively dispersing and pod opened after collection (photo to be inserted later-not available)	90%
5	Seed collected when pods very brown and dry, all open when collected from tree (photo to be inserted later-not available)	87%

Appendix B, Tables

TABLE 1. Summary Planting Table, Beal Phase I

Total Acres =		55.70											
Field	Acres	Planting Method	Date Planted	Species	Date Collected	Plant Material Source	# Source Plants	Amnt. Seed (lbs)	# Branches	Irrigation Schedule	Soil EC @0-1',1-3',3-5' mS/cm	Water Table Min-Max (ft)	Elev.
A	5.1	covercrop	15Jan2003	Solum barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a	Mar-Apr 03 Daily	3.18 (avg. of 2)	3.3-4.8	460
		Hydroseed	24Apr03	Baccharis sp.	16&17Dec02	BWRNWR-Kohen Ranch	<6	10	N/A	Apr-Jun03 1x/wk	0-1' = 25.7	2.2 - 3.7	458.9
				Bebbia juncea aspera	"	"	>10	(see Seed		June-Oct03 1x/mo	1-3' = 8.09		
				B. sarothoides	23Dec02	Pratt Reveg-Yuma, AZ	>20	Info table			3-5' = 4.45		
				Atriplex lentiformis	Purchased	Granite Seed	unk.	for % of					
				A. canascens	"	1697 W. 2100 North		each					
				A. polycarpa	"	Lehi, UT 84043	unk.	spp.)					
				Phacelia campanularia	"		unk.						
				Encelia farinosa	"								
				(see Table 2 for details)									
		Potted Plants	21&22Apr04	Prosopis pubescens	Purchased	CRIT 272 Ahahav Tribal Nursery	N/A	N/A					
B	2.4	covercrop	15Jan2003	Solum barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a	Mar-Apr03 Daily	3.18 (avg. of 2)	3.3-4.8	460
		Potted Plants	28May-5Jun03	2,195 Populus	Purchased	CRIT Ahahav Tribal Nursery Parker, AZ	unk.	N/A	N/A	Jun-Oct03 1x/wk	2.58 2.04	3.1-4.6	459.8
											0.95		

TABLE 1. Summary Planting Table, Beal Phase I

Total Acres =		55.70											
Field	Acres	Planting Method	Date Planted	Species	Date Collected	Plant Material Source	# Source Plants	Amnt. Seed (lbs)	# Branches	Irrigation Schedule	Soil EC @0-1',1-3',3-5' mS/cm	Water Table Min-Max (ft)	Elev.
C	3.6	covercrop	15Jan2003	Solum barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a	Mar-Apr03 Daily	3.18 (avg. of 2)	3.3-4.8	460
		covercrop	June 2003	regreen	purchased	Seed Solutions, Denver, CO		1000lb					
		Potted Plants	21Jan-3Feb	3900 P. fremontii	purchased	CRIT Ahahav Tribal Nursery	n/a			Apr-Oct03 1x/wk	1.5 (avg. of 2)		
			2004	200 S. exigua	purchased	Parker, AZ	n/a				1.3 (avg. of 2)		
D	5.4	covercrop Potted Plants	15Jan2003 28May- 5-Jun-03 21Jan-3Feb 2004	Solum barley 3500 Salix gooddingii 200 P. fremontii 1800 S. gooddingii	purchased Purchased " " "	Fertizona, Buckeye, Arizona CRIT Ahahav Parker, AZ "	n/a n/a	? N/A	n/a N/A	Mar-Apr03 Daily May-Oct03 1x/wk	3.18 (avg. of 2) 0-1' = 3.18 3-5 ' = 1.31	3.3-4.8 2.0-3.5	460 458.7
E	3.9	covercrop	15Jan2003	Solum barley	m	Fertizona, Buckeye, Arizona	n/a	?	n/a	Mar-Apr03	3.18 (avg. of 2)	3.3-4.8	460
		Hydroseed (SW edge	24Apr03	Baccharis sp.	16&17Dec02	BWRNWR-Kohen Ranch	<6	5.12	N/A	Apr-Jun03 1x/wk	4.46	2.8-4.3	459.5
		only)		Bebbia juncea aspera	"	"	>10			June-Oct03 1x/mo	1.91		
				B. sarathoides	23Dec02	Pratt Reveg-Yuma, AZ	>20				1.65		
				Atriplex lentiformis	Purchased	Granite Seed	unk.						
				A. canascens	"	1697 W. 2100 N.	unk.						
				A. polycarpa	"	Lehi, UT 84043	unk.						
				Phacelia campanularia	"	unk.							
				Encelia farinosa	"								

TABLE 1. Summary Planting Table, Beal Phase I

Total Acres =		55.70											
Field	Acres	Planting Method	Date Planted	Species	Date Collected	Plant Material Source	# Source Plants	Amnt. Seed (lbs)	# Branches	Irrigation Schedule	Soil EC @0-1',1-3',3-5' mS/cm	Water Table Min-Max (ft)	Elev.
		Potted Plants	28May-	2000 Salix exigua	Purchased	CRIT Ahahav Tribal Nursery	unk.	N/A	N/A		4.46 1.91	2.8-4.3	
			5Jun03	100 Populus		(cuttings							
				Fremontii		collected locally) Parker, AZ							
		Potted Plants	21&22Apr04	272 Prosopis pubescens	Purchased	" "					1.65		
F	4.1	covercrop	15Jan2003	Solum barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a	Mar-Apr03 Daily	3.18 (avg. of 2)	3.3-4.8	460
		Hydroseeded	3Apr03	P. fremontii	26Mar03	HNWR, Pintail Slough area	+10			Apr-May03 daily	2.65	2.6-4.1	459.3
				S. gooddingii	27Mar03	Yuma, AZ, along Gila R., Pratt	<10	20		May-Oct03 1x/wk	2.57		
				S. gooddingii	1Apr03	BWRNWR	7				2.19		
				S. gooddingii	2Apr03	BWRNWR	10						
				S. gooddingii	2Apr03	CRIT Ahakav Preserve	1						
				P. fremontii	2Apr03	BWRNWR	1						
				S. gooddingii									
		Branches	24Jun03		17Jun03	HNWR, between LCR&levy Rd	24		638				
		Hand seeded (spread on surface of wet soil)	20 May04	S. gooddingii	17May04	HNWR, between	12	15	n/a	weekly			
G	1.0	covercrop	15Jan2003	Solum barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a	Mar-Apr03 Daily	3.18 (avg. of 2)	3.3-4.8	460
		Hydroseeded (experime-ntal field)	3Apr03	S. gooddingii	27Mar03	Yuma, AZ, along Gila R.	<10	5		Apr-May03 daily	5.06	3.3-4.8	460

TABLE 1. Summary Planting Table, Beal Phase I

Total Acres =	55.70											
Field	Acres	Planting Method	Date Planted	Species	Date Collected	Plant Material Source	# Source Plants	Amnt. Seed (lbs)	# Branches	Irrigation Schedule	Soil EC @0-1',1-3',3-5' mS/cm	Water Table Min-Max (ft)	Elev.
				S. gooddingii	1Apr03	BWRNWR	7			May-Oct03	0.79		
				P. fremontii	2Apr03	BWRNWR	10				0.63		
				S. gooddingii	2Apr03	BWRNWR	1						
			1Aug03		24Jul03	Lake Mohave, 6 Mile Cove	6	6	N/A				
H	2.7	covercrop	15Jan2003	Solum barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a	Mar-Apr03 Daily	3.18 (avg. of 2)	3.3-4.8	460
		Hydroseeding	10Apr03	S. gooddingii	8Apr03	BWRNWR	unk.	8	N/A	Apr-May03 daily	1.38	2.9-4.4	459.6
		(onlyNE1/ 3field, 1ac, hydroseeded)			9Apr03	Yuma, AZ- Navajo Bridge on road to Betty's Kitchen &Pratt Site	<10			May-Oct03 1x/wk 1.08	1.16		
				P. fremontii	7&8Apr03	L. Mohave, RV Park	<10	2.5					
		Hand Seeded	25Apr03	S. gooddingii	18&22Apr03	BWRNWR	<5	2	N/A				
		(seed spread on surface of receding	19Jun03	S. gooddingii	17Jun03	HNWR, Between Levy Road and LCR	24	unk.	unknown				
		water)			18Jun03	L.Mohave, Pot Cove	6	unk.	unknown				
		Hand seeded	4June04	S. gooddingii	30May-3June	HNWR,	12	13	n/a				
		(spread on surface of wet soil)			2004	Between Levy Road and LCR							
I	4.3	covercrop	15Jan2003	Solum barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a	Mar-Apr03 Daily	3.18 (avg. of 2)	3.3-4.8	460
		Potted Plants	28May-	2,500 S. gooddingii	Purchased	CRIT Ahakhav Tribal Nursery	unkwn	N/A	N/A	May-Oct03 1x/wk	8.99	1.8-3.3	458.5
			5Jun03	1,500 Salix exigua		(cuttings collected locally) Parker, AZ				2.20		1.29	

TABLE 1. Summary Planting Table, Beal Phase I

Total Acres =	55.70												
Field	Acres	Planting Method	Date Planted	Species	Date Collected	Plant Material Source	# Source Plants	Amnt. Seed (lbs)	# Branches	Irrigation Schedule	Soil EC @0-1',1-3',3-5' mS/cm	Water Table Min-Max (ft)	Elev.
J	3.6	covercrop	15Jan2003	Solum barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a	Mar-Apr03 Daily	3.18 (avg. of 2)	3.3-4.8	460
		Potted Plants	28May-	3,200 Salix exigua	Purchased	CRIT Ahakhav	unk.	N/A	N/A	May-Oct03	7.03	1.8-3.3	458.5
			5Jun03			Tribal Nursery				1x/wk			
						(cuttings						3.36	
						collected locally)						2.34	
						Parker, AZ							
K	2.5	covercrop	15Jan2003	Solum barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a	Mar-Apr03 Daily	3.18 (avg. of 2)	3.3-4.8	460
		Hydroseeding	10Apr03	S. gooddingii	8Apr03	BWRNWR	unk.	16	N/A	Apr-May03 daily	5.10	2.8-4.3	459.5
		(onlyNE1/	9Apr03			Yuma, AZ-Navajo	<10			May-Oct03	6.10		
		3field, 1ac, hydroseeded)				Bridge on road to Betty's Kitchen & Pratt Site				1x/wk	1.76		
				P. fremontii	8Apr03	L. Mohave,	<10	5					
						RV Park							
		Hand-seeded											
		(seed spread	24Apr03	S. gooddingii	18&22Apr03	BWRNWR	<5	2					
		on surface											
		of receding											
		water)											
		Hand-seeded	19Jun03	S. gooddingii	17Jun03	HNWR, Between Levy Road and LCR	24	unk.	unk.				
		Branches	18Jun03	L.Mohave, Pot			6	unk.	unk.				
		Hand seeded (spread on surface of wet soil)	4June2004	S. gooddingii	30May-3June	HNWR, Between Levy Road and LCR	12	13	n/a				
L	4.2	covercrop	15Jan2003	Solum barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a	Mar-Apr03 Daily	3.18 (avg. of 2)	3.3-4.8	460
		covercrop	Jun-03	regreen	purchased	Seed Solutions, Denver, CO				May-Oct 1x/wk	1.75		

TABLE 1. Summary Planting Table, Beal Phase I

Total Acres =		55.70											
Field	Acres	Planting Method	Date Planted	Species	Date Collected	Plant Material Source	# Source Plants	Amnt. Seed (lbs)	# Branches	Irrigation Schedule	Soil EC @0-1',1-3',3-5' mS/cm	Water Table Min-Max (ft)	Elev.
			21Jan-3Feb	2000 S. exigua	purchased	CRIT Nursery, Parker, AZ							
				1350 S. gooddingii									
				3350 P. fremontii									
											0.89		
M	2.6	covercrop	15Jan2003	Solum barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a	Mar-Apr03 Daily	3.18 (avg. of 2)	3.3-4.8	460
		Hydroseed	20Mar03	P. fremontii	17Mar03	HNWR, Nursery	7	2.4	N/A	May-Oct03 1x/wk	3.77	2.7-4.2	459.4
					18Mar03	BWRNWR (gate to 1st river crossing)	10			May-Oct03 1x/wk	3.95		
					19Mar03	BWRNWR,	11				3.12		
						Mineral Wash BWRNWR (Dwnstrm of Mineral Wash)	5						
						BWRNWR,	2						
						Kohen Ranch							
		Hand seeded (spread on surface of wet soil)	4June04	S. gooddingii	30May-3June 2004	HNWR, Between Levy Road and LCR	12	13	n/a				
		Potted Plants	16Nov04	2265 (est.) P. fremontii									
N	6.2	covercrop	15Jan2003	Solum barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a	Mar-Apr03 Daily	3.18 (avg. of 2)	3.3-4.8	460
		Hydroseeded	20Mar03	Baccharis sp.	16&17Dec02	BWRNWR-	<6	223.1	N/A	Apr-Jun03	11.77	2.1-3.6	458.8
						Kohen Ranch				1x/wk			
				Bebbia juncea aspera	"		>10			June-Oct03 1x/mo	19.40		
		B. sarathoides	23Dec02	Pratt Reveg- Yuma, AZ			>20				22.10		

TABLE 1. Summary Planting Table, Beal Phase I

Field	Acres	Planting Method	Date Planted	Species	Date Collected	Plant Material Source	# Source Plants	Amnt. Seed (lbs)	# Branches	Irrigation Schedule	Soil EC @0-1',1-3',3-5' mS/cm	Water Table Min-Max (ft)	Elev.
Total Acres =		55.70											
				Atriplex lentiformis	Purchased	Granite Seed	unk.						
				A. canascens	"	1697 W. 2100 N.	unk.						
				A. polycarpa	"	Lehi, UT 84043	unk.						
				Phacelia campanularia	"		unk.						
				Encelia farinosa	"		unk.						
				(see Table 2 for details)									
O	2.5	covercrop	15Jan2003	Solum barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a	Mar-Apr03 Daily	3.18 (avg. of 2)	3.3-4.8	460
		container plants	21&22 Apr04	900 P. fremontii	purchased	CRIT nursery				May-Oct03 1x/wk	2.34 2.43		
P	2.6	covercrop	15Jan2003	Solum barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a	Mar-Apr03 Daily	3.18 (avg. of 2)	3.3-4.8	460
		container plants	21&22 Apr04	1800 P. fremontii	purchased	CRIT nursery				May-Oct 03 1x/wk	4.04		
											2.49		
Q	2.9		15Jan2003	Solum barley	purchased	Fertizona, Buckeye, Arizona	n/a	?	n/a	Mar-Apr03 Daily	3.18 (avg. of 2)	3.3-4.8	460
		Hydroseeding	10Apr03	S. gooddingii	8Apr03	BWRNWR	unk.	8		Apr-May	2.61	3.0-4.5	459.7
		(onlyNE1/ 3field, 1ac,			9Apr03	Yuma, AZ-	<10			Daily May-Oct03	0.61		
		hydroseeded)				Navajo Bridge on road to Betty's Kitchen& Pratt Site				1x/wk	1.08		
				P. fremontii	7&8Apr03	L. Mohave, RV Park	<10	2.5					

TABLE 1. Summary Planting Table, Beal Phase I

Total Acres =	55.70												
Field	**Acres**	**Planting Method**	**Date Planted**	**Species**	**Date Collected**	**Plant Material Source**	**# Source Plants**	**Amnt. Seed (lbs)**	**# Branches**	**Irrigation Schedule**	**Soil EC @0-1',1-3',3-5' mS/cm**	**Water Table Min-Max (ft)**	**Elev.**
		Hand Seeded	25Apr03	S. gooddingii	18&22Apr03	BWRNWR <5							
		(seed spread on surface of receding water) Branches	12Jun03	S. gooddingii	11Jun03	L. Mohave, Pot Cove	6		251				
		(seed laden branches stuck into ground, flooded)			12Jun03	HNWR, betwn Levy Rd.&LCR	4						
		Hand seeded (spread on surface of wet soil)	4June2004	S. gooddingii	30May-3June	HNWR, betwn Levy Rd.&LCR	12	13	n/a				

TABLE 2. SEED PHENOLOGY, BILL WILLIAMS, LOWER GILA AND LOWER CO. RIVERS

LOCATION	SPECIES	DATE	STATUS
Bill Williams River	**Fremont Cottonwood, *Populus fremontii***	**6 Feb**	**Green seed clusters visible on trees**
		3 Mar	**Seed Dispersal begins**
		19 Mar	**Some trees still dispersing, some finished**
		2 Apr	**Most trees finished dispersing, a few still have seeds**
		15 Apr	**No seed dispersal observed**
	Goodding willow, *Salix Gooddingii*	**31 Jan**	**Flower buds observed on trees**
		3 Mar	**Flowers present on female trees, most flowers on male trees still green and unopened, some are yellowish and open**
		19 Mar	**No seed dispersal yet, trees heavy with green clusters**
		2 Apr	**Many trees seeding**
		15 Apr	**Trees in full seed dispersal**
		18 Apr	**Seed declining, but still present**
		23 Apr	**Seed still present on few trees**
Havasu NWR @ tree nursery near maintenance yard, cw in maintenance yard, mature trees near Pintail Slough	**Fremont Cottonwood and Goodding willow**	**“ “**	**Same phenology as BWR trees; all trees planted from cuttings taken from BWR**
@ along Levy Rd.	**Fremont Cottonwood**	**??**	**Cottonwoods associated with mainstem of LCR are not as available at HNWR, none collected**
	Goodding Willow	**3 May**	**Willows heavy with all green seed capsules, no dispersal observed**
		12 May	**Mostly green seed pods, very little seed dispersal started on a few trees i.e 1-2 capsules on catkin may be yellowish and dispersing seed, o seed collection**
		17 May	**Most trees still not seeding much, but a few are dispersing and approximately 20 lbs seed collected in one morning (amount includes chaf, leaves and debris as well)**
		12-17 June	**Full Seed Dispersal**
Lake Mohave @Cottonwood Cove RV Park	**Fremont Cottonwood**	**1-8 Apr**	**Full Seed dispersal from mature trees throughout RV park**
	No willow present	**N/A**	
@Pot Cove, AZ side	**Goodding Willow**	**11-18 June-**	**Seed collected 11-18 June, but seed present and abundant through July**
@6 Mile Cove, NV side	**Goodding Willow**	**24 July**	**Not many trees present, but all seeding**
Yuma, AZ	**Fremont Cottonwood**	**27 Mar**	**Lower Gila R. & Laguna Dam near BLM’s Betty’s Kitchen Recr. Area - abundant seed dispersal**
YUMA, AZ	**Goodding Willow**	**27 Mar- 9 April**	**Full seed dispersal**

TABLE 3. SALT-TOLERANT SEED MIX (planted in Fields N, northern edge of A and southern edges of J and E)		
SPECIES	TOTAL(lbs)	%Total
Baccharis sp.	0.60	0.4%
Bebbia juncea aspera	0.45	0.2%
B. sarathoides	3.40	1.4%
Atriplex lentiformis	67.40	28.0%
A. canascens	31.40	12.9%
A. polycarpa	37.20	15.3%
Phacelia campanularia	24.60	9.7%
Encelia farinosa	78.20	32.1%
Total	243.25	100.0%

TABLE 4. WATER USE AT BEAL SITE DURING 2004 GROWING SEASON							
	JAN	FEB	MARCH	APRIL	MAY*	JUNE	JULY
Gallons X 10,000	n/a	n/a	1,413	4,065	6,374	11,487	8,907
Acre Feet			43.4	124.8	195.6	352.5	273
Acres irrigated			55.7	55.7	104.5	104.5	104.5

*Irrigation of 48.8 additional acres of Regreen™ began in May 2004.

TABLE 5. SOIL SAMPLING RESULTS, 12/03/2002

UNITED STATES BUREAU OF RECLAMATION
LOWER COLORADO REGIONAL LABORATORY
** BEAL LAKE SOILS: Complete Report **
Dates Sampled: 12/03/02 & 12/12/02
Samples Received: 12/05/02 & 12/16/02
Samples Analyzed: 02/18/03

Lab No.	Site No.	Sample Depth (feet)	% Saturation	ECe mS/cm	% Sand	Textural Classification % Silt	% Clay	Laboratory Texture
022939	A	0 - 1	32.1	25.70	81.4	13.0	5.6	Loamy Sand
022940	A	1 - 3	33.5	8.09	96.3	1.6	2.1	Sand
022941	A	3 - 5	31.8	4.45	97.9	0.1	2.0	Sand
022942	B	0 - 1	29.0	2.58	90.9	6.3	2.8	Sand
022943	B	1 - 3	32.9	2.04	96.0	1.8	2.2	Sand
022944	B	3 - 5	31.9	0.95	97.4	0.7	1.9	Sand
022945	C	0 - 1	32.6	3.34	87.4	9.4	3.2	Sand
022946	C	1 - 3	32.1	0.73	96.8	1.2	2.0	Sand
022947	C	3 - 5	31.2	0.52	98.2	0.0	1.8	Sand
022948	C-2	0 - 1	32.2	3.01	94.4	2.4	3.2	Sand
022949	C-2	1 - 3	32.4	2.27	96.5	1.1	2.4	Sand
022950	C-2	3 - 5	31.9	2.10	95.9	1.9	2.2	Sand
022951	DD	0 - 1	31.9	4.26	86.6	8.1	5.3	Loamy Sand
022952	DD	1 - 3	31.8	3.28	96.4	0.8	2.8	Sand
022953	DD	3 - 5	32.6	1.60	97.0	0.8	2.2	Sand
022954	E	0 - 1	32.9	4.46	96.2	1.0	2.8	Sand
022955	E	1 - 3	32.6	1.91	97.7	0.0	2.3	Sand
022956	E	3 - 5	33.1	1.65	95.9	1.1	3.0	Sand
022957	F	0 - 1	32.2	2.65	93.2	3.8	3.0	Sand
022958	F	1 - 3	33.3	2.57	96.7	0.4	2.9	Sand
022959	F	3 - 5	34.3	2.19	96.8	0.8	2.4	Sand
022960	G	0 - 1	39.1	5.06	84.7	10.0	5.3	Loamy Sand
022961	G	1 - 3	33.1	0.79	97.0	0.8	2.2	Sand
022962	G	3 - 5	33.9	0.63	97.4	0.6	2.0	Sand
022963	H	0 - 1	30.2	1.38	94.3	3.4	2.3	Sand
022964	H	1 - 3	32.0	1.16	99.1	0.0	0.9	Sand
022965	H	3 - 5	33.3	1.08	96.6	0.7	2.7	Sand
022966	ii	0 - 1	31.5	8.99	96.9	0.3	2.8	Sand
022967	ii	1 - 3	31.9	2.20	97.3	0.3	2.4	Sand
022968	ii	3 - 5	30.3	1.29	97.8	0.2	2.0	Sand
022969	J	0 - 1	32.7	7.03	96.6	0.8	2.6	Sand

TABLE 5. SOIL SAMPLING RESULTS, 12/03/2002

UNITED STATES BUREAU OF RECLAMATION
LOWER COLORADO REGIONAL LABORATORY
** BEAL LAKE SOILS: Complete Report **

Dates Sampled: 12/03/02 & 12/12/02
Samples Received: 12/05/02 & 12/16/02
Samples Analyzed: 02/18/03

Lab No.	Site No.	Sample Depth (feet)	% Saturation	ECe mS/cm	% Sand	Textural Classification % Silt	% Clay	Laboratory Texture
022970	J	1 - 3	31.8	3.36	97.8	0.6	1.6	Sand
022971	J	3 - 5	32.8	2.34	97.7	0.0	2.3	Sand
022972	Q	0 - 1	34.2	2.61	92.8	3.9	3.3	Sand
022973	Q	1 - 3	31.6	0.61	97.8	0.6	1.6	Sand
022974	Q	3 - 5	33.3	1.08	97.0	1.0	2.0	Sand
022975	K	0 - 1	27.5	5.10	94.5	4.0	1.5	Sand
022976	K	1 - 3	33.9	6.10	70.6	21.2	8.2	Sandy Loam
022977	K	3 - 5	30.0	1.76	98.0	0.9	1.1	Sand
022978	L	0 - 1	29.1	3.20	92.9	5.7	1.4	Sand
022979	L	1 - 3	32.6	1.75	94.3	3.8	1.9	Sand
022980	L	3 - 5	31.1	0.89	96.1	2.7	1.2	Sand
022981	M	0 - 1	31.6	3.77	97.3	1.6	1.1	Sand
022982	M	1 - 3	31.2	3.95	97.9	1.4	0.7	Sand
022983	M	3 - 5	33.7	3.12	97.4	2.6	0.0	Sand
022984	N	0 - 1	34.6	11.77	73.2	22.2	4.6	Sandy Loam
022985	N	1 - 3	33.2	19.40	87.6	9.8	2.6	Sand
022986	N	3 - 5	41.4	22.10	31.6	59.3	9.1	Silt Loam
022987	O	0 - 1	29.5	2.02	97.1	0.0	2.9	Sand
022988	O	1 - 3	31.4	2.34	97.7	0.0	2.3	Sand
022989	O	3 - 5	30.0	2.43	95.6	1.2	3.2	Sand
022990	P	0 - 1	29.7	5.35	91.9	4.2	3.9	Sand
022991	P	1 - 3	33.7	4.04	94.7	2.2	3.1	Sand
022992	P	3 - 5	31.6	2.49	97.4	0.2	2.4	Sand

TABLE 6. SOIL SAMPLING RESULTS, 9/11/2003

UNITED STATES BUREAU OF RECLAMATION
LOWER COLORADO REGIONAL LABORATORY
** BEAL LAKE SOILS: Complete Report **
"(samples taken to determine differences in vegetation growth in these fields after planting, see other soils file for original soil data)"
Date Sampled: 9/11/03
Samples Received: 9/11/03
Samples Analyzed: 12/18/03

Lab No.	Field No.	% Saturation	ECe mS/cm	Nitrate mg/kg dry soil	Ortho-Phosphate mg/kg dry soil	Ammonia mg/kg dry soil	% Sand	Textural Classification % Silt	% Clay	Laboratory Texture
031821	C1 North	29.0	3.84	8.92	0.03	0.46	74.7	19.0	6.3	Sandy Loam
031822	C2 N	31.4	0.79	2.18	0.08	0.17	96.1	2.2	1.7	Sand
031823	C3 N	32.3	1.90	6.31	0.08	0.31	94.1	4.1	1.8	Sand
031824	C1 South	28.3	0.75	3.29	0.08	0.20	94.2	4.1	1.7	Sand
031825	C2 S	30.4	0.66	4.83	0.08	0.29	97.3	1.7	1.0	Sand
031826	C3 S	29.7	1.14	5.44	0.19	0.12	97.5	1.3	1.2	Sand
031827	G1 North	33.2	0.94	2.72	0.10	0.35	92.6	4.8	2.6	Sand
031828	G2 N	33.2	0.80	3.84	0.06	0.21	97.3	1.9	0.8	Sand
031829	G3 N	32.0	1.26	5.22	0.05	0.10	96.6	2.3	1.1	Sand
031830	G1 South	48.5	4.47	4.26	0.06	0.61	5.0	82.1	12.9	Silt Loam
031831	G2 S	30.9	1.35	14.81	0.09	0.04	97.2	1.8	1.0	Sand
031832	G3 S	30.7	1.84	7.54	0.05	0.28	95.7	2.7	1.6	Sand
031833	H1 North	37.3	2.16	18.74	0.07	0.88	82.9	14.4	2.7	Loamy Sand
031834	H2 N	31.2	2.58	9.70	0.03	0.07	93.0	6.0	1.0	Sand
031835	H3 N	30.4	1.79	7.08	0.03	0.05	95.6	4.1	0.3	Sand
031836	H1 South	32.4	0.42	3.14	0.04	0.05	97.2	2.1	0.7	Sand
031837	H2 S	28.2	0.64	2.49	0.03	0.06	94.2	5.5	0.3	Sand
031838	H3 S	32.9	1.14	3.72	0.02	0.08	97.6	2.0	0.4	Sand
031839	K1 North	28.1	0.56	4.82	0.06	0.09	94.7	3.5	1.8	Sand
031840	K2 N	30.7	0.58	1.44	0.05	0.10	97.3	1.9	0.8	Sand
031841	K3 N	30.2	1.02	1.50	0.18	0.12	97.7	1.9	0.4	Sand
031842	K1 South	32.2	0.54	4.15	0.07	0.12	95.4	3.6	1.0	Sand
031843	K2 S	29.0	0.58	2.17	0.06	0.04	97.0	2.2	0.8	Sand
031844	K3 S	31.4	1.24	6.27	0.04	0.06	96.8	2.1	1.1	Sand
031845	O1 North	28.7	0.52	4.11	0.07	0.06	96.6	2.7	0.7	Sand
031846	O2 N	30.9	0.68	3.09	0.04	0.04	97.9	1.4	0.7	Sand
031847	O3 N	28.0	1.38	4.50	0.03	0.06	97.8	1.9	0.3	Sand
031848	O1 Sout h	30.3	0.98	4.15	0.53	0.05	97.1	2.2	0.7	Sand
031849	O2 S	29.4	0.58	2.17	0.06	0.04	98.1	1.5	0.4	Sand
031850	O3 S	29.4	1.09	6.27	0.04	0.09	97.8	1.4	0.8	Sand

TABLE 7. SEED AGES AND GERMINATION TEST RESULTS FROM FIELD OBSERVATIONS

Species	Developmental Stage	# days since collected	% Germination
Cottonwood [1-5] *(Populus fremontii)*	1	9-10	56
	1	12-33	58
	2	9-10	78
	3 or 4	23	98
	3 or 4	17	58
	3	9-10	98
	4	9-10	90
	5	9-10	87
	3	17	58
	3	23	98
	3	12-33	58
Willow [1-4] *(Salix gooddingii)*	1	16-40	18
	2	15-36	21
	3	15-23	88
	4	15-22	99
	3-4	30-38	63
	3 (branches cut from tree, seeds remained on branch from 14-19 April, then sent to lab)	41-55	54

Cottonwood Developmental Stages:
[1]Seed pods collected green but known to have opened prior to testing. No ripe pods observed on tree.
[2]Very green pods, unopened at the time of collection, may or may not have opened prior to testing (78% viable). No ripe pods observed on tree.
[3]Seed pods opened slightly and/or at least one pod open on the cluster when collected-(98% viable).
[4]Seeds collected either as "fluff"; pods completely opened and dispersing from tree-(90% viable).
[5] Seed pods collected were brown, pods shells dry, some fluffy seed still present (87% viable).

Willow Developmental Stages:
[1]Pods/capsules collected green and known to have opened prior to testing (18% viable). No ripe pods seen on tree.
[2]Pods very green and unopened when collected from tree, may or may not have opened prior to testing (21% viable). No ripe pods seen on tree.
[3] Pods/capsules yellowish, but very few opened when collected from tree (88% viable).
[4]Completely open pods, fluff all over the catkin while still on tree (99% viable).

TABLE 8. BEAL LAKE, PHASE 1, COSTS

Project Description: Clear 56 acres of saltcedar, arrowweed, etc, build berms/roads around fields, plant area with cover crop of solum barley and/or RegreenTM, irrigate cover crop with Rain-for-Rent equipment, install permanent flood irrigation system, hydroseed 22 acres via contractor, irrigate with Rain-for-Rent until germination and establishment, plant remaining 34ac with container plants, re-seed areas if needed, continue to irrigate with flood irrigation.

Task	Unit	Agency	Cost		
Pump, Platform, Fuel Tank					
Surveying, prep. of as-built drawings, proj. management		USBR	$16,500.00		
Pump & Platform Design		USBR	$17,500.00		
Materials- Pump, motor, platform materials, fencing, fuel line tubing and other req'd materials		USBR	$80,000.00		
Fuel Tank and required materials		USBR	$16,865.00		
Installation of platform, pump, fencing, ConVault Diesel tank and double wall fuel line tubing		USBR	$80,000.00		
				Sub-total	$210,865.00
Site Preparation					
Clearing & Rootplowing	55ac @ $ 930/ac	FWS-HNWR	$51,150.00		
Irrigation Materials & Installation					
4000 linear feet, 24"" dia. Pipe"	4000' @ 12.67/ft		$50,680.00		
Pipe Fittings	N/A		$49,233.00		
Installation of Pipe	4000' @ $59/ft	USBR-YAO	$236,000.00		
				Sub-total	$387,063.00
Planting and Irrigation					
Planting Plan Development		USBR-RO	$520.00		
Sprinkler Irrigation (56ac, four months)			$39,921.00		
Cover Crop Seed Purchase Solum Barley		USBR-RO	$1,710.00		
""" "" Regreen™"		USBR-RO	$2,499.00		
Cover Crop Planting		FWS-HNWR			
	1 GS 9 @ 45/hr x 16 hr		$720.00		
	Fuel		$110.00		
Hydroseeding					
Seed Collection Costs:	5 Fed Employees	USBR-RO			
	1GS 12 @ 65/hr x 8 x 5				
	1GS 9 @ 45/hr x 8 x 5		$1,960.00		
	2 GS 6 @ 24/hr x 8 x 5		$1,920.00		
	Fuel for vehicle (approx.)		$200.00		
Travel Costs / Per Diem	5 Fed employees @ $500/week		$2,500.00		
Seed Testing	4@$20;1@$18.50;7@$23		$259.50		
Hydroseeding Contract:					
Seed Not Included	950/acre x 6.5 ac		$8,125.00		
Seed Included 1250/acre x 15.5 ac	" $14,725.00 "				
1 gal. Container Plants	33, 000@2.45ea, inc.delivery		$80,850.00		
Hydroseeding Equipment (small portable unit)	ea		$1,495.00		
				Sub-total	$157,514.50
Maintenance For ALL Phases					
Labor for irrigation per year	1 GS 9 @ 120 days @ $392/day		$47,040.00		
Fuel for Pump- Irrigation per year	6 @ $1,670 per month	USBR/FWS	$25,058.00		
				Sub-total	$72,098.00
GRAND TOTAL					$827,540.50